CHAPTER 7

TEMPERATURE MEASUREMENTS

7-1. General. The resistance thermometer and thermocouple are types of instruments that will measure temperature in concrete. In mass concrete, temperature changes are the primary causes of volume change and stress. The temperature rise within the concrete causes an outward expansion during the early life of the concrete. The temperature of the internal mass is higher than that of the exposed surfaces. Thus, as the outer surface cools and tends to shrink, compressive stresses develop internally, and tensile stresses externally. In order to determine the effect of temperature on the stress and volume change, temperatures may be measured at a number of points within the structure, as well as at the boundaries. However, it is not necessary to determine the detailed temperature history of every portion of the structure. It is considered sufficient to select those portions which are typical and those which are most severe. Design temperature histories will give information on these locations. Thermocouples are suitable for measuring temperature under certain conditions and at several locations. However, resistance thermometers are preferred over thermocouples because they have been found to be more dependable, of greater precision and less complicated in their operation. One type of layout would be to place a thermometer every 50 ft in cross section and elevation in a monolith of a large massive structure. For a small structure, a finer spacing may be desirable. A few thermometers should be placed near and in the dam faces to evaluate the daily and weekly fluctuations in temperature. Another layout commonly used is in selected lines of thermometers parallel and transverse to the dam axis, and in a vertical direction. The spacing of the instruments may be very close at exposed faces, and quite wide in the more uniform temperature interior. Lines near or crossing construction joints usually have instruments close to the joint because of the effect of new concrete placed against the older.

7-2. Temperature Measuring Devices.

a. Resistance Thermometer. The resistance thermometer, a Carlson type instrument described in detail in paragraph 2-7, consists of a non-inductively-wound coil of enameled copper wire enclosed in a brass case. The thermometer is provided with 30 in. of three-conductor, rubber-covered cable. Two conductors are connected to one end of the coil, and one to the other end. This three-conductor arrangement 'eliminates the effect of total resistance and resistance changes in the conductor leads when used with a Carlson testing set. This is accomplished by having one conductor in each of two arms of a Wheatstone bridge, such that they cancel one another. The resistance of the thermometer is 39.00 ohms at 0^{o} F increasing exactly 0.10 ohm per degree Fahrenheit.

b. Thermocouples. When two dissimilar metal wires are joined together, a small d-c voltage is developed in this electrical circuit at each junction. Since the two voltages are opposite and direct, the net voltage is proportional to the temperature difference between the junctions. By placing a potentiometer in the circuit and measuring the net voltage, the temperature difference is found. Insulated thermocouple wire is available commercially in many combinations of metals, gages, and insulation types. Either copper-constantan or iron-constantan wire pairs are suitable for measuring concrete temperatures. Adequate sensitivity and sufficient strength and flexibility are secured with AWG 16 or 18 size wire. Conductor insulation and sheath for cable must be rubber or polyvinyl plastic. The special protective metallic or ceramic tubes used to house thermocouple elements are not considered necessary.

7-3. Installation. The thermometer or thermocouples may be installed by the contractor. Sufficient details should be shown on the contract drawings and adequate specifications provided to obtain required installation. Thermometers or thermocouples on a single horizontal plane within a lift is most easily done by placing them at the bottom of the lift. An adequate length of three-wire, rubber-insulated, rubber-covered stranded copper wire cable has to be attached from resistance thermometer location to the terminal board location. The thermometer or thermocouple should be taped or tied to the previous lift at the proper location. Thermometers located within about 3 ft of exposed concrete surfaces or bulkhead faces subject to daily temperature variations must be placed accurately at their intended distance from the surface or face. Thermometers or thermocouples in a vertical plane in a lift should be taped to a pole which is embedded in the previous lift. Wooden or plastic poles approximately 1/2-in. diameter should be used. Metal poles and reinforcing bars should not be used. Identification tags attached to the cable should be used to accurately identify thermocouple or thermometer. Special installation is required for a thermocouple that is not required for resistance thermometers. A clear distance of at least 1 ft should be maintained between thermocouples. Extension cable from the thermocouple location to the terminal board must be kept at least 1 ft away from an a-c line. Also a closed cabinet and interior heating should be provided at all reading stations.

7-4. Collection of Data. The resistance thermometer or thermocouple is read with a potentiometer. There are commercially available portable, semiautomatic and automatic types. The selection of the type should be based on the number of instruments that are to be read. The initial readings should be taken 1 to 3 hr after installation, then two or three readings at 12-hr intervals thereafter, then daily for the next 20 days, twice weekly for the next month, once weekly for the remainder of the construction period, and every other week during operation of the project. Readings may be discontinued when three years of final stable temperatures or annual cycle of temperature are obtained.

7-5. Processing of Data. Copies of readings should be maintained and temperature histories performed by the Engineering Division, except during construction of the project they may be maintained by construction personnel with copies of data supplied to the Engineering Division.